

SOIL SURVEY OF THURSTON COUNTY, NEBRASKA.

By A. H. MEYER and M. W. BECK, of the U. S. Department of Agriculture, and
W. A. ROCKIE, of the Nebraska Soil Survey.

DESCRIPTION OF THE AREA.

Thurston County is located in the northeastern part of Nebraska, bordering on the State of Iowa about 15 miles south of Sioux City. It is bounded on the north by Dixon and Dakota Counties, on the east by the Missouri River, on the south by Burt and Cuming Counties, and on the west by Wayne County. The county is 31 miles long from east to west, and 18 miles wide. It comprises an area of 387 square miles, or 247,680 acres.

The county as a whole is a portion of the loess plain, into which streams have cut and produced the minor features of relief, the upland and the alluvial lands, the latter consisting of high terraces and present river flood plains. In the upland there are three types of topography—hilly, rolling, and flat.

The hilly portion is confined to the section northeast of the divide between Logan Creek on the west and Omaha Creek and the Missouri River on the east. The divide is high and almost entirely reduced to slopes, though a number of narrow plainlike areas remain. It may be traced as follows: Crossing the northern county line near Emerson, it extends to the southeast to within a mile of Rosalie, where it swings to the east for 5 miles and then extending slightly east of south crosses into Burt County. This section, as the name implies, is hilly and the slopes are steep and occasionally precipitous. It is almost completely dissected by erosion and the drainage is intricate. There are very few sharply cut drainage ways, except in the bluff zone, and the hills are well rounded, a conspicuous feature of the topography. The depth of dissection is about 400 feet along the Missouri River and less toward the west. In general, the roughest topography of this division is in a narrow zone about 4 or 5 miles wide along the Missouri River, where the slopes are very steep to precipitous or blufflike. Cliffs 10 to 50 feet in height are common. The divides are narrow and very

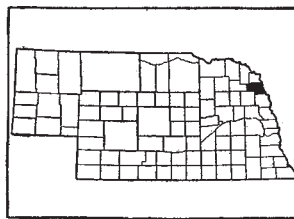


FIG. 57.—Sketch map showing location of the Thurston County area, Nebraska.

little, if any, of the constructional surface remains. The hilly section comprises about 180 square miles

The rolling section is confined to the Logan Creek drainage system, southwest of the main divide. The dissection here, ranging from 150 to 200 feet, is not nearly so deep as in the hilly section. The divides are not so narrow, though scarcely ever flat. Southeast of Rosalie there is an area of about 6 square miles where the surface configuration is gently rolling and the gradient of streams is slight. It is closely associated with a number of flat areas.

The flat areas largely form a part of the main divide, though a few are found southeast of Rosalie and a number in the southeastern part of the county. They form a part of the original constructional surface level, being remnants of the loess plains.

In general, the transition from upland to terrace is a moderately gentle slope and from upland to first bottom rather steep and, in a few instances along the Missouri River, precipitous.

The terraces or benches of Thurston County comprise the lowest or first terraces, second or medium terraces, and the third or highest terraces. The terraces are mostly confined to the Logan Valley. The highest terraces occur 7 miles northwest of Pender, along the county line, and at Rosalie. They are generally flat, though in detail somewhat eroded, and it is debatable whether they should be considered terraces or uplands. The medium and low terraces are flat and bench-like, with occasional knolls and dissections caused largely by streams rising in the upland. As a whole the terraces are narrow and discontinuous. The height of the third terrace is 80 to 100 feet, of the second 30 to 40 feet, and of the first 10 to 20 feet, above the present flood plains. The slope between the terraces and bottom land is usually gentle, except where the streams impinge sharply against the terraces. According to a benchmark of the U. S. Department of Agriculture, Drainage Division, at Pender, the elevation above sea level of the second terrace at that point is 1,347.15 feet.

The bottom land in Thurston County is rather extensive. The largest areas occur along Logan Creek and the Missouri River. Other developments exist along Omaha, North Omaha, South Omaha, South Blackbird, North Blackbird, and Middle Creeks. The areas are generally flat. On the Logan Creek bottom land there are numerous cut-offs, old channels, lakes, and depressions, and the same is true of the Missouri River bottoms on a much larger scale.

Thurston County is drained by three principal streams, the Missouri River and Logan and Omaha Creeks. The general direction of the drainage is to the southeast. Omaha Creek is an exception to this, as it flows due north, though its larger branches flow southeast. There are no dams to furnish water power in the county. Lawless Lake is the only lake in the county.

The first settlement in Thurston County was made in 1884 on Logan Creek in the immediate vicinity of the present site of Pender. The allotment of the Omaha Indian land was made in 1884, and in the same year all of that portion of the Omaha Reservation lying west of the right of way of the Chicago, St. Paul, Minneapolis & Omaha Railway was opened to settlement. Thurston County was organized in 1889, with Pender as the county seat. People from the surrounding counties settled in the county and bought land under the provisions of the allotting act. The Winnebago Indian land was allotted in 1889 and later under an act of Congress of 1897. The Winnebago Reservation is in the northern part of the county and the Omaha reserve in the southeastern part, east of the old-settled section.

The present population consists largely of native whites and Indians, except in the southwestern part, where Germans and Bohemians are numerically predominant. The Indians are in large part confined to the eastern part of the county.

The population of Thurston County, according to the United States census reports, has increased rapidly. In 1890 the population is reported as 3,176, and in 1910 as 8,704. In 1909 there were 22.5 persons to the square mile. There are about 1,000 Indians in the county.

Pender, the county seat, with a population of 804, is in the southwestern part of the county in the Logan Valley. It is an important distributing point for agricultural implements and supplies, and has four elevators. Walthill, with a population of 810, the largest town in the county, is located in the east-central part. This town has four grain elevators, a cement-block machine factory, and is a prominent Indian trading point. Emerson is an incorporated town of 838 people, partly in each of the three counties, Thurston, Dixon, and Dakota. Winnebago, Rosalie, and Thurston are small railroad points. Macy is a small town in the eastern part of the county. The Omaha Indian Agency is at Macy, and the Winnebago Indian Agency is located $1\frac{1}{4}$ miles southeast of Winnebago.

Thurston County is fairly well supplied with railroads, except in the southeastern corner, where the distance to a station ranges from 8 to 16 miles. The Chicago, Burlington & Quincy Railroad passes north and south through the eastern part of the county, and the Chicago, St. Paul, Minneapolis & Omaha Railway through the western part. These lines give good traffic connections with Sioux City, Omaha, and Lincoln.

Most of the wagon roads are on section lines or land lines except in the northeastern and eastern part of the county, where they follow contours to a considerable extent, and where the roads are less substantial. There are only a few dirt roads in the county that are graded and kept in good condition. Most of the highways receive

little attention, and in many places substantial bridges are lacking. There are no toll roads in the county.

Rural mail delivery service reaches practically all farming communities, and the telephone is in common use in the more thickly settled parts of the county.

CLIMATE.

The climate of Thurston County is typical of eastern Nebraska. According to the records of the Tekamah station, the mean annual temperature is 49.5° F. January and February have a mean temperature of about 22° F., and July, the warmest month, has a mean of about 75° , while the mean for August is only 2 degrees lower. There is a range in means between the coldest and warmest months of about 53° . The lowest temperature recorded is -33° and the highest 108° F.

The average date of the first killing frost in the fall is October 1, and of the last in the spring April 27. The date of the earliest recorded killing frost in the fall is September 13 and of the latest in the spring May 27. The average length of the growing season is 157 days.

The mean annual precipitation is 32 inches. The precipitation is heaviest in the months of May, June, and July. The total for the summer months—June, July, and August—averages 14.52 inches. Rainfall is lightest in winter, with a seasonal mean for December, January, and February of 2.69 inches. The rainfall is somewhat heavier in this region than in the southeastern part of the State, and averages about 3.5 inches more than at Lincoln.

The greater part of the precipitation in the summer occurs in local storms. The rainfall in May and June is well distributed, periods of drought being practically unknown. In July the distribution is less favorable, and in August and September the rainfall is much lighter, and droughts occur occasionally in these three months. In general, however, there is sufficient rainfall within the growing season to prevent serious injury to crops where the moisture is properly conserved, and total crop failures do not occur, although corn is sometimes injured by drought, especially on the lighter textured soils.

The amount of snowfall varies annually from a few inches to several feet.

From October 1 to April 1 the prevailing wind is from the northwest, and from April 1 to October 1 it is from a southerly direction. Strong winds are common, though tornadoes are rare.

According to the Weather Bureau records at Sioux City, Iowa, the relative humidity is fairly uniform. The average annual humidity is about 70 per cent. The records show that about one-half of the days

of the year are clear, about one-fourth cloudy, and the remainder partly cloudy.

The climate is very favorable to the general farm crops. The long, warm summers especially favor such crops as corn.

There is a Weather Bureau station in Thurston County, at Walthill, but the records cover too short a period to be of much value. The following table is compiled from the records kept at Tekamah, in Burt County, and the data are believed to be accurately representative of local conditions:

Normal monthly, seasonal, and annual temperature and precipitation at Tekamah, Burt County.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	° F.	° F.	° F.	Inches.	Inches.	Inches.
December.....	26.4	62	-20	0.92	2.85	0.27
January.....	22.3	63	-33	.75	1.50	.03
February.....	22.0	78	-33	1.02	.80	.93
Winter.....	23.6			2.69	5.15	1.23
March.....	36.5	89	- 6	1.48	1.23	1.08
April.....	51.3	94	13	3.13	5.09	3.57
May.....	61.0	100	23	4.44	.61	10.97
Spring.....	49.6			9.05	6.93	15.62
June.....	70.0	100	35	6.18	4.92	3.24
July.....	75.0	108	41	4.55	.88	7.31
August.....	73.0	104	39	3.79	3.06	12.12
Summer.....	72.7			14.52	8.86	22.67
September.....	65.6	104	23	2.77	.57	3.83
October.....	53.4	93	13	1.85	2.01	1.43
November.....	37.5	75	-15	1.12	.32	1.83
Fall.....	52.2			5.74	2.90	7.09
Year.....	49.5	108	-33	32.00	23.84	46.61

AGRICULTURE.

Agriculture in Thurston County dates from 1884, when a part of the Omaha Indian Reservation was opened for settlement. Prior to that the Indians cultivated a few patches of land throughout the county for their subsistence. The southwestern corner was opened in 1884 and the remainder of the county was reserved for the Omaha and Winnebago Indians. In 1902 Congress passed an act permitting

the heirs of deceased Indians to sell, with the approval of the Secretary of the Interior, any allotted Indian land held by heirship. The sales of Indian land brought in settlers, and to-day about one-third of the land is owned by white people.

About 8 per cent of the county is in forest. All of the terraces were originally covered with prairie grasses. Only the narrow first bottoms and narrow strips on the bottom lands in the upland region along the larger streams were and are forested with elm, ash, oak, cottonwood, and willows. There is some timber, largely cottonwood and willows, with some elm and box elder, along the stream and abandoned channels of the Missouri River. In the upland most of the timber is confined to the bluff zone of the Missouri River. Where it is not disturbed it is becoming more extensive by advancing up the draws. In the bluff zone the forest growth is mainly bur oak, basswood, elm, ash, bitter hickory, and walnut, accompanied by an underbrush of hazel bush, sumac, ironwood, dogwood, and prickly ash.

From the first, corn has been the chief money crop, though wheat, oats, and flax were not neglected. Only a small acreage was devoted to potatoes, barley, and rye. Sorghum was grown for sirup. In 1889 the census reports 14,835 acres in corn, with a production of 568,519 bushels; 1,888 acres in wheat, with a production of 30,143 bushels; and 1,503 acres in oats, giving 39,689 bushels. Hay was cut from 7,977 acres and produced 11,454 tons. Of the minor crops, there were 414 acres of flax, with a production of 3,053 bushels; 156 acres of potatoes, giving 13,042 bushels; 36 acres of barley, giving 819 bushels, and 20 acres of rye, producing 342 bushels.

Within the next decade the acreage of all the crops was greatly extended, especially of corn and wheat. As reported by the census, there were 58,683 acres in corn, producing 1,761,190 bushels, and 36,524 acres in wheat, producing 430,230 bushels, in 1899. The wheat acreage was at its highest at this period. Since then it has declined considerably. This is also true of flax, of which none apparently was grown in 1914. The acreage of wild hay has fallen off only slightly.

With the construction of the Chicago, Burlington & Quincy Railroad through the eastern part of the county in 1906, giving direct connection with Sioux City, many white people entered the reservations and either bought or rented the land. Before the coming of the railroad hardly 1 acre out of 50 was in cultivation in the eastern part of the county. Most of the land was utilized for grazing.

Thurston County is new agriculturally, except for a strip in the southwestern corner, where the land has been under cultivation for about 30 years. The present agriculture consists primarily of grain production and secondarily of dairying and the raising of hogs and

other live stock. Corn, oats, wild hay, barley, wheat, timothy and clover, timothy, alfalfa, millet, or Hungarian grass, and potatoes are the chief crops, ranking in acreage in the order named.

The type of farming practiced is uniform throughout the county, except that the relative importance of the various crops differs with the sections. More beef cattle are kept on the bottom lands than on the upland soils. Scarcely any live stock is raised by the farmers in the reservations, except by the white people who own their land.

Corn is easily the predominating crop in Thurston County. About 54 per cent of the improved land in farms is devoted to it. The acreage of corn has undoubtedly reached its height, as the farmers are beginning to give more attention to other crops. The present tendency is to produce less corn. Corn is grown on all the soil types, though most extensively on the Marshall silt loam. Some of the highest yields are obtained on the Missouri River bottoms. The 1910 census reports 88,793 acres in corn in 1909, producing 3,364,582 bushels. The average yield for the county is about 37 bushels per acre. This yield is 10 to 15 bushels higher than the average for southeastern Nebraska. Reids Yellow Dent and Iowa Silver Mine are the chief varieties of corn grown. Most of the corn is listed, though considerable checking is done.

On the reservations most of the corn is sold, while outside a large part is fed to hogs and beef cattle. Good profits are realized by marketing corn in the form of pork. The ears are husked from the standing stalks and it is a common practice to pile the ear corn in the open. A large part is spoiled by being stored in this way. This practice is mostly confined to tenant land leased from Indians, where the tenant must make his own improvements. The farmers who can afford it usually have corn cribs. After the ears have been removed the cornfields are used for fall and winter pasture. There are only a few silos in the county.

Corn does not have a definite position in a systematic crop rotation. Frequently corn is planted in the same field 4 to 6 years, and on the bottom land it is not uncommon for a farmer to plant a field in corn for 10 years or more. Corn does best where it is rotated with small-grain and leguminous crops.

Oats are second in acreage to corn. About 12 per cent of the improved land in farms is in oats. The census reports a total of 20,105 acres in oats in 1909, with a production of 525,771 bushels. The average yield for the county is about 26 bushels per acre. It is doubtful whether the acreage of oats will be much extended, for the crop is reported by farmers as not a very profitable one, though one still essential for stock feed and as a step in the rotation. It is not practical to follow corn with winter wheat and as a rule oats occupy this place in the rotation. Oats do well on all the upland and terrace

soils, but are not adapted to the bottom land, as there they grow too rank and lodge. The Kherson, a very short, stiff-strawed variety, has given the best results on the bottom land. Oats are seldom sowed in succession. Most of the crop is fed to horses, a small part to other live stock, and very little is sold.

The wild hay consists of marsh and prairie grasses. With the installation of a comprehensive drainage system and the further breaking up of the native sod, the acreage of wild hay is certain to decrease rapidly. The 1910 census reports 9,047 acres of wild grasses cut in 1909 with a production of 13,990 tons. Most of the wild hay is cut on the bottom lands of the county and in Logan Valley. Only a small percentage of the upland remains in virgin prairie and this is mostly pastured. Practically all of the hay is stacked in the field with modern devices, and later, if to be sold, is baled. Where used for feed it is taken from the stacks as needed. A number of farmers on the upland own, and others rent, small hay lots on the bottom land. In general, most of the hay is fed on the farm, though a considerable quantity is marketed in the home towns and some is shipped out. Wild hay brings \$6 to \$10 a ton, depending on the quality.

Barley is one of the principal cereal crops. It is largely confined to the southwestern corner of the county and is grown mostly on the Marshall silt loam. It does well and is considered more profitable than oats. Of late its acreage has decreased and winter wheat seems to be taking its place. For 1909 the census reports 7,305 acres in barley with a production of 137,189 bushels.

The census shows a rather small acreage of wheat in 1909, only 4,812 acres, with a production of 74,010 bushels. The wheat acreage was at its highest about 1900, when, owing to the low yields of spring wheat, the production was greatly reduced. Scarcely any spring wheat or soft winter-wheat varieties are grown. Recently a winter variety, Turkey Red, has been introduced, and wheat is becoming more important. At present the wheat acreage is higher than in 1909, and the tendency is toward still further increase. The Turkey Red is more desirable than other winter-wheat varieties because it passes through the winter better. It is superior to the spring varieties because it produces heavier, can be sowed in the fall when farm work is less pressing, and withstands drought better, as it matures before the dry, hot winds occur.

Wheat is grown chiefly on the Marshall and Waukesha silt loam types. It is usually grown one year or two years and follows oats in the rotation. Wheat is strictly a cash crop, and most of it is sold directly from the thrashing machine, although some is stored in granaries.

Of the tame or cultivated grasses, timothy and clover mixed are most important. According to the census, 2,355 tons were cut from

1,243 acres in 1909. It is only within the last decade that this combination has been extensively grown. In a short crop rotation it is more desirable than alfalfa, which is usually left in a field from five to seven years. Though it has this advantage over alfalfa, the difficulty of getting a good stand has discouraged farmers, and most of them are now turning to alfalfa for a hay crop.

If the rainfall is favorable at the time it is most needed, that is, immediately after the cutting of the grain nurse crop, clover does well, yielding $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. Quite a large acreage is in timothy alone, sowed for hay. Timothy is especially desirable for use as horse feed, where no wild hay is available, and some is sowed for seed production. The 1910 census reports 903 acres in timothy, producing 1,751 tons. A small acreage is devoted to millet, or Hungarian grass, and the other tame grasses. According to the census, 481 acres were devoted to millet, or Hungarian grass, in 1909, with a cutting of 992 tons, and 210 acres to other tame grasses, producing 326 tons. Thirty acres of grains were cut green and produced 78 tons, and there were 56 acres in coarse forage, producing 175 tons.

Alfalfa has become very popular in Thurston County, and its acreage is being rapidly extended. Its high feeding value, together with its beneficial effects on the soil, makes it a very desirable crop. In 1909 a total of 551 acres is reported, as compared with 13 acres in 1899. The production in 1909 was 1,894 tons, an average of about 3.5 tons per acre. This legume is admirably adapted to the Marshall, Knox, and Waukesha silt loams and to the well-drained bottom lands, but is mostly grown on the first named two types. It does not do so well on the sandy terrace and upland soils. Alfalfa is usually sowed after wheat, and the stand maintained five to seven years, and in some cases considerably longer. In the reservations the legume has been grown only a few years, and scarcely any of the fields have been plowed up. Alfalfa requires a mellow seed bed, well compacted, and does best where it is sowed immediately after the first rain in August. Fifteen pounds of seed per acre is considered sufficient to insure a good stand.

A few acres of sorghum are grown. It yields about 35 bushels of seed and 90 gallons of sirup per acre. The stalks make good stock feed.

Scarcely any trucking is carried on, except in a small way in the vicinity of the towns. The farmers generally plan to grow enough potatoes for home use and occasionally have some to sell. Potatoes, on an average, are grown on about one-half acre per farm. Vegetables are grown on almost every farm, though not always enough to supply even the home demand. In 1909, 437 acres were devoted to potatoes, with a harvest of 40,046 bushels, and 206 acres were in other vegetables.

There are no bearing orchards of any size, except in the northwestern part of the county. A considerable number of orchards are being set out on farms in the reservations. With proper attention to pruning, spraying, fertilizing, and cultivation, apples, pears, and plums do well. Only a few peaches are grown. The value of all orchard products, including small fruits and nuts, is given in the 1910 census as \$5,485.

In the vicinity of Pender, in the longer settled section, considerable attention is directed to dairying. The number of cows varies from 4 to 10 head to the farm, with an average of about 6. The milk is separated at home and the cream is shipped, chiefly through cream stations, to Omaha or Sioux City. Some farmers ship directly and gain 2 cents a pound on butterfat. There are three cream stations at Pender, one at Thurston, and two at Walthill. Owing to the lack of substantial barns on most of the farms on the Indian reservations, little attention is given to dairying there, except to supply the home demand. With the passing of the land from the Indians to the whites more attention is certain to be given to this industry. Most of the milch cows are of Shorthorn and Hereford breeding, with some Guernsey and Holstein.

Beef production is the chief type of farming followed on the Logan Valley bottom lands. Outside of this area there do not appear to be many herds of beef cattle. The chief breeds are Shorthorn and Hereford, with some Red Poll and Galloway. The herds range in size from 25 to 100 head or more. The cattle are commonly pastured on the poorly drained areas of Wabash silt loam, and the better drained areas are used to furnish corn and fodder for winter feed. Considerable wild hay is also fed. Most of the beef cattle are shipped to South Omaha. A few farmers fatten cattle purchased from the stockyards.

Hog raising is confined largely to the southwestern part of the county, though small herds and occasional large herds are found throughout the Indian reservations. In the former section the average number of hogs kept on a farm is about 35, though some farms have as many as 100. On the reservations the average is about 15 head, though at least one farmer on the Missouri River bottoms reports 1,000 head. On a few farms all the corn grown is fed to hogs, and usually this method is profitable. Practically every farmer supplies his family with pork and sells the remainder of the hogs to the middleman, who usually ships to the stockyards at South Omaha. Duroc Jersey, Poland China, and Chester White are the chief breeds. Very few of the herds are purebred. Though hog cholera is prevalent, it has been remarkably well controlled during the last few years.

Practically all of the farm operations are performed by horse labor. Both the farm and draft types are raised. Nearly every farmer raises one or two colts a year and many farmers raise more. The Indians prefer to raise light horses, such as are well suited to riding and driving. Of the heavy types the Percheron is most popular. More mules are being raised, and at present about 15 per cent of the colts are mules.

There are a few flocks of sheep in the county. A considerable number of feeders are imported every year in the western part of the county, fattened, and sold to the South Omaha packing plants when the prices are favorable. One farmer, at least, feeds 600 to 1,000 head every year.

In general little live stock is kept on the reservation lands, except on farms owned by white people. Stock raising is largely restricted to the longer settled sections of the county. The value of all live stock in Thurston County is given in the 1910 census as \$1,685,335.

Fifty to one hundred chickens are usually kept on the farm. Most of them are of mixed breed. Ducks, geese, and turkeys are raised. The value of poultry and eggs produced in 1909 in Thurston County is reported as \$80,043.

On the Indian reservations most of the farms are operated by tenants. In the longer settled sections most of the land is farmed by the owners. On land operated by owners considerable attention is given to the proper cultivation of crops, seed selection, crop rotation, and fertilization. Alfalfa is grown on the soils low in organic matter, and a good deal of forethought is given to maintaining the productiveness of the soils. The tenants do not pay much attention to these practices and usually grow those crops or series of crops which give the largest immediate returns.

The adaptation of crops to certain soils has not been carefully studied. It is recognized that corn does better on the Marshall silt loam than on the Knox silt loam and produces the highest yields on the well-drained bottom-land soils. On the other hand, wheat, barley, and oats do better on the black upland and terrace soils than on the rich first bottoms. The Sarpy very fine sandy loam is better adapted to special, intensive crops than to general farm crops.

Systematic rotation of crops is followed by only a few farmers. The tenants pay little or no attention to rotation. The general plan is to grow corn two or four years, oats one year, and wheat one year or two years, returning to corn. Occasionally the wheat land is seeded either to clover and timothy or to alfalfa. The former stand is usually maintained for two or three years and the latter five to seven years, and then return is made to corn. Although clover and timothy fits better as a step in a crop rotation, alfalfa is taking the place of this com-

bination owing to the difficulty of getting a stand of clover. Fields in which corn has been grown for 10 years or more are not uncommon. A rotation which is considered very good by some of the best farmers consists of two years corn, one year oats, two years wheat, and two years clover and timothy. The second crop of clover is turned under.

A paramount problem in Thurston County is the prevention of erosion. Even within the short time that the hilly section has been under cultivation, numerous areas have been deprived of their organic-matter content by surface wash. In the progress of the soil survey it was noticed that after a heavy rain considerable surface soil was washed from the hills and deposited at the foot of slopes. Thus far scarcely any steps have been taken to prevent erosion.

Owing to the extensive methods of farming, there is a great laxity in cultivation. As a rule, the soil is plowed only 3 or 4 inches deep, and this practice, in many places where it has been continued, has resulted in the formation of a plowsole. On the better managed farms deeper plowing has been done, with beneficial results, among them the lessening of erosion. The 4-horse hitch is used for practically all farm operations and heavy horses and strong implements are in general use. Stubble is usually plowed in the fall, either for winter wheat or corn, except where the soil drifts; here it is plowed in the spring. Alfalfa land is best plowed in the spring to prevent the growth of a volunteer crop. It is desirable to plow the ground as soon as the previous crop has been harvested. When corn follows itself the field is usually disked twice, or possibly oftener, to cut the corn stalks and loosen the ground before listing the corn. Some use the lister on the old corn field and check in the furrow. According to reports from farmers, this method is better than either listing or checking. When corn is put on sod it seems advisable to list. When oats are put on corn land the preparation of the land consists of cutting the stalks with the disk and then plowing or disking a number of times before drilling the oats. A considerable number of farmers broadcast and cultivate or disk the seed in. The latter is not considered an efficient method, for as a rule it results in decreased yields.

Very little manure is used and practically no commercial fertilizer. What manure is produced is generally applied to the Knox silt loam areas and on land for corn. Scarcely any green crops are plowed under. In the census for 1910 no expenditure for commercial fertilizers is reported.

Outside the reservations proper the buildings are substantial and are kept in good repair. In the reservations the buildings are usually cheap, although where the land has passed into white ownership large houses and commodious barns have been erected. The

more progressive Indians also have good buildings. Most of the fences are of barbed wire, though woven wire is coming into use. Modern labor-saving machines are in general use over the entire county. As a rule, the farm machinery is not sheltered.

Farm labor is plentiful, but it is rather difficult to obtain efficient help. Where laborers are hired for the entire year they usually receive \$25 to \$35 a month, with board and washing. Most of the laborers are hired for 8 or 9 months. They receive a slightly higher wage. During the period of corn plowing hired help is paid \$1.50 to \$2 per day, and during corn-husking season they are paid 4 cents a bushel, with room and board. Where families are hired the wage is usually \$400 a year, in addition to the allowance of a house, cow, chickens, and a small plot of ground for a garden. A large part of the farm work, however, is done by the family, the women and children sometimes working in the fields. An expenditure of \$199,043 for labor, or \$417.28 per farm reporting, is shown in the 1910 census.

There are 186,001 acres in farms in Thurston County, according to the census of 1910, of which 164,628 acres are improved. The average size of farms is given as 169.1 acres. This is quite a decrease from that of 1890, when it was given as 346 acres. Of the total value of all farm property, 79.5 per cent is represented by the land, 6.4 per cent by buildings, 2.3 per cent by implements, and 11.7 per cent by farm animals, including poultry, etc. About one-third of the farms are operated by owners and two-thirds by tenants.

Both the cash and share systems are used in renting farms. The cash rental is by far the more popular. Indian land is leased by the Department of the Interior to white people for \$1.50 to \$5 an acre, depending on the quality of the land. The length of the lease has been increased to 5 years, and it embodies a clause which requires the tenants to put 20 per cent of the farm into alfalfa. All the improvements, buildings, fences, etc., must be made by the tenant, but they are his property when he leaves the place. Where the land is rented from white people all improvements are provided, and cash rent varies from \$3 to \$7 an acre, depending on the type of the soil. Under the share system where the owner receives two-fifths of the crops grown all implements and stock are furnished by the tenant. Where land is rented on the basis of an equal division of the crops, the owner furnishes the implements, work stock, and seed. In any system of renting the tenant is required to deliver the grain to the elevator.

Farm values in the county range from \$30 to \$225 an acre, depending on the character of the soil, improvements, and location.

SOILS.

The soils of Thurston County are grouped into three distinct divisions—upland, terrace, and first-bottom soils. The upland embraces the Marshall, Knox, Carrington, Thurston, and Lindley series; the terrace, the Waukesha and Sioux series; and the first bottoms, the Wabash and Sarpy series and Riverwash. As to color, the soils are classified as dark brown, brown, and light brown. There is considerable range in texture, from clay through silt loam, loam, sandy loam, and very fine sandy loam to sand. Most of the soils are friable and permeable throughout the 3-foot section, but the Wabash clay is plastic and impervious. With the exception of the Lindley, Knox, and Sarpy series, the soils are high in organic matter.

Originally the entire county was covered with a thick mantle of loess, but only remnant areas of the original constructional surface exist now. These areas are flat and the soil is the Marshall silt loam, flat phase. Most of the loess has a destructional configuration, the dissection varying from 400 feet in the eastern part of the county to 150 feet in the western part. The cutting down extends through the silt layer along most of the streams into the underlying glacial drift, and in some cases through the latter to the Dakota sandstone. As the loess has been carried down the slope by slide action and erosion, very little drift is exposed, except where there has been recent active erosion. The loess varies in thickness from zero to about 70 feet. It varies in color from brownish yellow, yellow, or light gray to almost white and is always more or less impregnated with lime and blotched and streaked with iron stains. The loess beds give rise to the Marshall silt loam and where the original surface soil has been eroded to Knox silt loam. Along the Missouri River bluff the loess has been modified by material blown over it from the sand and silt bars of the stream. The lower part of the loess carries considerable sand.

The glacial geology has not been definitely worked out by the State geologists and hence only general statements can be made. Below the loess lies the sand plain which is quite well developed in the northwestern part of Thurston County. The plain is not continuous, and its extent is not known. The sand bed is yellow to light gray in color and medium sand in texture, with a known thickness of 40 to 60 feet. The sand bed gives rise to the Thurston sandy loam and sand.

Over much of the county the loess, in the hilly land, rests on the Kansan drift. Apparently the Kansan drift extends under the sand plain, but as it does not enter into the soil formation it is not very important. The Kansan drift is exposed only along streams where there has been pronounced recent erosion. Owing to the washing

down and slipping of silts from the higher lying areas, the soil material is an intimate mixture of loess and drift. It is classified as Carrington silt loam where the soil contains pebbles and boulders, and as the Lindley silt loam where the original surface has simply been eroded.

Where the Kansan drift has not been modified by loess it gives rise to the Thurston loam. The Kansan sheet is distinctly till, and consists of a heterogeneous mass of clay, silt, sand, gravel, and boulders. It varies in color from yellow and brown to reddish brown and becomes lighter in color and mottled with depth. With the Kansan drift are associated sand beds whose exact geological history is not known. In most places where the Thurston loam has been mapped the sand stratum forms the subsoil.

Below the Kansan drift lies the Aftonian material, which consists largely of stratified sand and gravel and a few boulders. It crops out along the lower slopes of drainage ways. A good exposure is found $6\frac{1}{2}$ miles almost due east of Rosalie. It is mostly fine gravel. As so much of the overlying silt is mixed with the soil material the soil is mapped as the Thurston loam.

The lowermost drift sheet underlying the Aftonian consists of a blue clay containing numerous small pebbles and a considerable number of boulders. It is exposed only in deeply cut banks.

The Dakota formation of Cretaceous age forms the exposed bedrock of Thurston County. It consists largely of sandstone and includes some clay and slate, with lignite deposits. Outcrops of Dakota sandstone are found $1\frac{1}{2}$ miles northwest of Walthill, one-half mile north of Macy, and almost 6 miles east of Winnebago on the Missouri River bluff. It does not give rise to any soil types, though it has imparted a very sandy texture to the Thurston loam immediately south of Macy. Locally the Benton formation rests on the Dakota, but its extent is not known. Beginning with the lower bed, it consists of Graneros shale, Greenhorn limestone, and Carlile shale. There are no exposures in the county so far as known, as these formations are concealed by a heavy bed of mantle rock.

The bench or terrace soils of Thurston County consist of first, second, and third terraces. The third terrace is of later age than that of the loess plains, while the second and first are of still more recent origin. The terraces consist of fluvial silts which are very similar to the loess and sand. The first and second terraces in Logan Valley are underlain by sand and in places have no silt veneering. Where the terraces consist of silt and the sand is not generally reached with the 3-foot auger the soil is classified with the Waukesha silt loam. Where the sand is reached and there is considerable sand throughout the upper section of the soil the material is classified as Sioux loam. In one depression on the second terrace

of Waukesha silt loam the soil is typical of the Scott silt loam, mapped in other counties of eastern Nebraska.

The bottom-land soils along the smaller streams are very uniform in texture and color and consist largely of silt washed from the Marshall and Knox silt loam types. They are dark brown to black in color and give rise to the Wabash silt loam type. In the northwestern corner of the county considerable wash from the Thurston sandy loam has been mixed with the silt. This material is the same as the silt loam, except that it is a loam in texture, and it is mapped as Wabash loam. Along the Missouri River the alluvium is composed largely of alternate layers of very fine sand, silt, and clay. The dark-drab to black clay deposits, over 3 feet in depth, have given rise to the Wabash clay; the light-brown to brownish-gray deposits of silt, underlain by very fine sandy loam, to the Sarpy silt loam; and the same colored material over very fine sandy loam, underlain by a somewhat lighter colored and lighter textured very fine sandy loam, has given rise to the Sarpy very fine sandy loam. The recently deposited material along the streams occurring as sand, silt, or clay bars and flats is classed as Riverwash.

The names and extent of the several soils mapped in Thurston County are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam.....	153,344	62.8	Sarpy silt loam.....	3,008	1.2
Flat phase.....	2,176		Sioux loam.....	2,176	.9
Wabash silt loam.....	40,896	16.5	Wabash clay.....	1,344	.5
Knox silt loam.....	16,064	6.5	Wabash loam.....	1,088	.4
Carrington silt loam.....	6,656	2.7	Thurston loam.....	448	.2
Thurston sandy loam.....	6,016	2.4	Lindley silt loam.....	256	.1
Waukesha silt loam.....	5,888	2.4	Thurston sand.....	64	.1
Sarpy very fine sandy loam...	4,480	1.8			
Riverwash.....	3,776	1.5	Total.....	247,680

MARSHALL SERIES.

The Marshall soils are dark brown to black. The subsoils are yellowish brown to brownish yellow, and porous and friable. They are little, if any, heavier than the surface soils, and are usually calcareous. The types of this series differ from those of the Knox series in the relatively large quantity of organic matter in the surface soils. The topography is rolling, and artificial drainage is generally necessary for the best results with crops. In Thurston County only the silt loam type, with a flat phase, is identified.

MARSHALL SILT LOAM.

The soil of the Marshall silt loam consists of a dark-brown to black, moderately heavy silt loam, 4 to 15 inches deep. It is never dense black, but is prevailingly dark brown. The type is high in organic matter and has a very smooth and velvety feel. It breaks down to a fine powder. The subsoil consists of a yellowish-brown, more compact, heavy silt loam, with no apparent accumulation of clay. Below 30 to 36 inches light-gray mottlings and reddish stains are usually encountered, becoming more pronounced in the substratum. Deep cuts in this type show that the section below the 3-foot level is generally a yellowish-gray or light-gray silt loam, more or less blotched with reddish iron stains. The intermediate layer between soil and subsoil is usually of a brownish color and varies from 2 to 4 inches in thickness. The boundary line between soil and subsoil is marked by a gradual change in texture as well as in color. The structure of the upper portion of the subsoil is granular, while the lower portion, as well as the substratum, is columnar. The subsoil is highly calcareous, the lime existing chiefly in the form of concretions. Occasionally none are encountered in the 3-foot section.

In general the soil, as well as the subsoil, of the Marshall silt loam along the Missouri River bluff is looser and more open in structure than away from the bluff zone, and not so compact and heavy in texture. In the western part of the county there is a granular structure in the upper portion of the subsoil which is absent in the eastern part.

Owing to the destructional topography, erosion has produced considerable variation, largely in the depth of the surface soil. On the smoother, almost flat divides the soil is frequently 15 to 18 inches deep, while on the sharper divides, steep slopes, and points of hills it is very shallow. In the latter situations numerous spots, too small to indicate on the map, are entirely devoid of their original surface soil, and the yellowish-brown subsoil, with its limy concretions, is exposed. These spots are similar to the Knox silt loam mapped in this county. Again, on the lower slopes there has been considerable accumulation of soil and the depth may range from 18 inches to 3 feet or more. Along intermittent streams areas of colluvial material, too small to map, are included with this type. The eroded spots in this type are largely confined to the hilly section of the county.

In the northwestern corner of the county the loess covering over the sand is very thin, and through the process of erosion there has come about a rather intimate mixing. The marginal areas of the Marshall silt loam contain an appreciable quantity of sand, being a loam type, but owing to the patchy occurrence of the loam develop-

ments it is not practical to map them. In this section small areas of loam and sandy loam are included with this type. The sand drifts to some extent and has notably increased the sand content of the Marshall silt loam.

The Marshall and Knox silt loams differ in that the original surface material has been largely removed from the latter. The Knox silt loam is really an eroded phase of the Marshall silt loam. The two types are identical in texture and color of subsoil.

The Marshall silt loam is the dominant soil type. It covers 62.8 per cent of the area of the county and occurs throughout the entire upland region. In the northwestern part of the county it is more or less interspersed with the Thurston sandy loam, and northeast and east of the main divide with numerous small areas of Knox silt loam, and to a lesser extent with the other upland soil types.

South and southwest of the main divide the type occupies a rolling topography. The divides are rarely sharp and the slopes are moderate. Three miles southeast of Rosalie the configuration is gently rolling and the valley bottoms are wide in proportion to the size of the streams. Northeast and east of the divide the topography becomes steeply rolling and culminates in a roughly dissected bluff zone which varies from 2 to 4 miles in width. The slopes in the hilly section are generally steep and the divides narrow and crest-like. In the bluff zone this condition is even more pronounced and in places the slopes are precipitous. In the hilly section and bluff zone the steep slopes and sharp divides are usually occupied by the Knox silt loam, but not universally. Forested areas are usually composed of the Marshall silt loam. Southeast of Winnebago in the bluff zone scarcely any Knox silt loam is mapped. This section is almost entirely in timber and erosion has not been able to develop many Knox silt loam areas.

Erosion is a serious factor on many farms of this type. The acreage of the Knox silt loam is steadily increasing as a result of the removal of the surface soil of the Marshall silt loam. The most effective means of preventing further erosion are deeper plowing and keeping the steep slopes in cover crops as much as possible. Owing to its high organic-matter content, friable structure, and silty texture the soil withstands drought over protracted periods.

The Marshall silt loam is derived from the eroded loess plains material and, along the bluff zone, partly from silts blown on the upland from the Missouri Valley. The type was originally covered with a thick growth of prairie grasses, except along drainage ways and in the eastern part of the county, where it was forested. A large portion of the timber is left, and where not disturbed it is becoming more extensive. The natural growth is scrub oak, basswood, elm,

ash, bitter hickory, and black walnut, accompanied by an undergrowth of hazel bush, sumac, ironwood, dogwood, and prickly ash.

About 75 per cent of the type is under cultivation and the remainder is largely in native prairie and timber. Most of the unimproved land is in the eastern part of the county, where the topography is steepest. About two-thirds of the improved land is in corn and the remainder is largely devoted to oats, wheat, clover and timothy, and alfalfa. Corn is admirably adapted to this type and yields from 35 to 45 bushels per acre. When it is planted more than two years in succession the yield decreases noticeably. Oats rank second in acreage and yields range ordinarily from 30 to 40 bushels per acre. Winter wheat does well on this type and its acreage is being gradually extended. Usually 20 to 25 bushels of wheat are obtained per acre. Spring wheat yields only 12 to 15 bushels per acre. Barley is grown, but is apparently decreasing in acreage. It yields 25 to 35 bushels per acre.

In wet seasons clover and timothy do well, yielding $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. In dry seasons it is difficult to establish a stand, and as alfalfa is a more certain crop, it is becoming popular. Alfalfa does excellently on this type and usually three cuttings are made, with a total yield ranging from 3 to 5 tons per acre. The stand is usually maintained from 5 to 7 years and in some cases longer. The crop increases in yield until about the seventh year, when it begins to decline rapidly. A few farmers grow small patches of millet, which yields as a rule 3 tons per acre. Some of the type is still in native grasses, which yield from one-half to 1 ton per acre. A portion of it is pastured. On farms where there is no permanent pasture a good formula for seeding pasture land is 1 peck of timothy, 9 pounds of alsike, 3 pounds of red clover, and $2\frac{1}{2}$ pounds of white clover. The above ratio is used by a few of the most successful farmers, and, according to their reports, 20 acres of mixed pasture furnishes enough feed for 20 head of cattle.

A small quantity of sorghum is grown. It produces about 35 bushels of seed and 90 gallons of sirup per acre, and where cut for fodder about 8 tons. Potatoes do well and on the average yield 150 bushels per acre. The tendency on this type is to grow less corn and more wheat and leguminous crops and to keep more live stock.

While owners are directing more attention to crop rotation, scarcely any definite rotation is practiced by the majority of tenant farmers. The general tendency is to keep the same field in corn two to four years, oats one year, and wheat one year or two years. Occasionally the wheat field is either sowed to clover and timothy or alfalfa. As it is difficult to get a stand of clover and timothy as a rule, alfalfa is taking the place of this combination. The stand of clover and timothy is usually maintained for two or three years and

of alfalfa five to seven years. The last year clover and timothy is frequently pastured.

Owing to its silty, friable, and stone-free structure the typical Marshall silt loam is easy to handle. Where the slopes are steep the operation of farm implements is rather difficult and cumbersome. The soil can be worked under a wide range of moisture conditions, but if cultivated when too wet its physical condition is impaired. Four horses are used in performing most of the farm work.

This land responds readily to barnyard manure, which usually increases the yield about 25 per cent or more. Very little green manuring is practiced, and no commercial fertilizers are applied.

Under the present system of farming the productiveness of the soil is gradually decreasing, and notably so on the tenant farms.

The value of the typical Marshall silt loam ranges from \$50 to \$175 an acre, depending largely on the topography and to a minor extent on the location and improvements.

Marshall silt loam, flat phase.—The Marshall silt loam, flat phase, is a dark-brown to black, heavy silt loam, 12 to 18 inches deep, underlain by a heavy, yellowish-brown silt loam. The immediate layer between soil and subsoil varies from 2 to 4 inches in thickness and is of a brown color. At any point from 30 to 36 inches faint mottlings of light gray and brown appear. The subsoil is compact and hard when dry, though friable when moist. The upper part of the subsoil is decidedly granular, but changes gradually in the lowermost part to a vertical structure. The concentration of clay is not a conspicuous feature, though more marked than in the typical Marshall silt loam. The soil is rich in organic matter, and the lower subsoil or substratum is high in lime concretions.

This phase is similar to the typical Marshall silt loam in color and texture, but differs in that it has a more compact subsoil and a flat, plainlike, instead of a rolling, topography.

This phase is very inextensive, covering only 3.4 square miles, and occurs largely as a part of the main divide and as minor divides southeast of Rosalie and west of Pender. It has a smooth or plainlike configuration and is apparently a part of the original constructional topography. The streams have not cut back into the phase, but are near enough to provide adequate drainage. A few small depressions which are not so well drained occur in the phase. The Marshall silt loam, flat phase, is derived from the loess of the loess plains. The phase originally supported a thick growth of prairie grasses.

Practically all of the flat phase is under cultivation. The type of farming is similar to that on the typical Marshall silt loam. According to the reports of farmers, corn does better by 5 to 10 bushels on the rolling or typical Marshall silt loam, whereas wheat

and oats do better on this flat phase. A more uniform stand can be obtained on the flat phase, and this may account for the higher yield. The slight compaction of clay in the upper portion of the subsoil and the formation of a plow pan which prevents the free capillary movement of water probably explain the lower yield of corn. The experience of farmers is that when deeper plowing is resorted to, to break up the plowsole, the yields are higher, even for corn, than on the typical Marshall silt loam.

Owing to its flat topography, the operation of farm machinery is easier on the phase than on the typical soil. Land values range from \$125 to \$150 an acre.

KNOX SERIES.

The Knox soils are light brown in color, overlying yellowish-brown, moderately calcareous, porous, friable, and usually uncompacted subsoils. They are derived from loess and occur mainly in the hilly and rolling lands adjacent to the Missouri River Valley. In Thurston County the Knox silt loam is mapped.

KNOX SILT LOAM.

The soil of the Knox silt loam is a light-brown or yellowish-brown, friable silt loam, with an average depth of 6 inches. It has a very floury feel and, as the color indicates, is almost devoid of organic matter. The subsoil consists of a friable silt loam, yellowish brown or yellow, with a grayish tinge, and having light-gray mottlings and reddish iron stains in the lower portion. Occasionally the light-gray mottlings are very pronounced in the soil, and where such is the case the surface soil usually has a whitish appearance when dry. In the typical soil there is no apparent difference in texture or structure between soil and subsoil. The type has a pronounced open and columnar structure. The entire 3-foot section is high in lime and where erosion has been severe limy concretions are plentiful on the surface.

On virgin prairie and forested areas and on lower slopes of hills the soil is darker in color and approaches the Marshall silt loam type. In general the Knox silt loam is rather strictly confined to light-colored soil. Along the bluff it is coarser in texture and more friable than farther west.

The type occurs in numerous small areas scattered throughout the Marshall silt loam, chiefly northeast and east of the main divide. The areas are most plentiful in the bluff zone and less numerous westward. Only a few areas are found in the western and southwestern part of the county. The largest areas occur northeast of Winnebago. With the clearing of timber from the land the Knox silt loam tends to become more extensive.

The type occupies steep slopes and narrow divides and points between drainage ways. It is thoroughly drained and remarkably retentive of moisture, considering its low organic-matter content. It is subject to severe erosion.

The soil is derived from the eroded loess of the loess plains and along the Missouri River bluff in part from silts blown on the upland from the Missouri Valley. As mapped in Thurston County the type is equivalent to eroded areas of Marshall silt loam. The native vegetation of the Knox silt loam was prairie grasses, and along the Missouri River bluff, scrub oak, prickly ash, hazel bush, and sumac.

About 50 per cent of this type is under cultivation. As the type largely occurs in small areas, it is usually included with fields of Marshall silt loam. Corn, oats, wheat, and alfalfa are the chief crops grown. When the soil is not manured, yields are low and the crops yellow and of unhealthy appearance. Corn yields 10 to 20 bushels, wheat 10 to 15 bushels, and oats 15 to 20 bushels per acre. When a heavy application of manure is made the crop returns are about the same as on the Marshall silt loam when not manured. Considerable alfalfa is produced on this type, and if the land is heavily manured before it is seeded the crop does very well. Three cuttings are made, and occasionally four, with a total yield of 3 to 5 tons. Potatoes, when the land is manured, do better than on the Marshall silt loam. A large part of the type is still in native prairie grasses and such areas are largely used for pasturage.

Owing to the low content of organic matter, the soil is somewhat sticky, and it is not so easy to handle as the Marshall silt loam. The Knox silt loam usually receives all the barnyard manure produced on the farm, though the supply is generally not nearly sufficient. No commercial fertilizers are used, and up to the present time scarcely any green crops have been turned under. Keeping this soil in cover crops tends to retard the naturally serious erosion.

The value of land of this type ranges from \$30 to \$50 an acre, depending largely on the topographic position and location.

CARRINGTON SERIES.

The soils of the Carrington series are dark brown and occasionally black in color, overlying brown, faintly yellowish brown or faintly reddish brown silty to clayey subsoils, uniformly oxidized and free of mottlings. They are derived from glacial drift and occur in the northern humid part of the Mississippi basin. Their lime content is moderate to low and the topography is smooth. Only the silt loam member of the series is recognized in Thurston County.

CARRINGTON SILT LOAM.

The Carrington silt loam is a dark-brown, moderately heavy silt loam, 8 to 15 inches deep, with an average depth of 10 inches. The

soil is friable and high in organic matter. It is underlain by a brown silt loam, which passes immediately into a more compact, yellowish-brown silt loam. The type is similar to the Marshall silt loam, but differs in that it has a few pebbles and bowlders on the surface and in the soil section. In places bowlders are numerous on this type, but as a rule the stone content is low. Sand pockets occur rarely. Small areas of Carrington loam are included within this type as mapped. The type occurs in numerous small areas northeast and east of the main divide.

The Carrington silt loam occupies relatively steep slopes along streams and low points between drainage ways. A large quantity of silt, washed down from the higher lying land, is incorporated with the surface soil. The Carrington silt loam is usually developed where the erosion on the lower slopes has been in excess of the washing and slipping down of the loess cap. The type contains numerous draws, and in places so many as to make the slopes rather broken. The drainage is thorough and erosion is a serious factor. The soil withstands drought well.

The soil is derived from the Kansan drift sheet, with which, however, during the process of erosion a large quantity of silt has been incorporated. The type was originally covered with prairie grasses, except along the lower slopes of the principal drainage ways, where it was forested.

Most of the type is in native prairie grass and is largely used for pasturage and to some extent for hay land. Corn does fairly well and yields 35 to 45 bushels per acre. When the soil receives liberal applications of barnyard manure general farm crops do well. Alfalfa does excellently, and, owing to the steep slope of the land, it is better suited to this crop than to any other. It is generally recognized by farmers that the Carrington silt loam should be kept in cover crops as much as possible and the broken areas in permanent pasture.

This soil works up into a mellow condition and can be cultivated under a wide range of moisture conditions. Only a small quantity of manure is applied and no commercial fertilizers are used.

The type ranges in value from \$50 to \$80 an acre, depending upon the stone content, topography, and location.

THURSTON SERIES.

The soils of the Thurston series range in color from brown to dark brown and in rare cases to almost black, and the subsoils from yellow to light brown with sometimes a reddish tinge. The soils have a considerable range in texture, but coarse sand and fine gravel are usually present. The subsoils consist of a mass of loose sand and gravel with low water-holding capacity. The soils of this

series are derived from sandy and gravelly noncalcareous glacial materials. This series differs from the Otisville in the prevailing darker color of its soil. In this county the series is represented by the loam, sandy loam, and sand types.

THURSTON LOAM.

The soil of the Thurston loam is a medium-brown to dark-brown loam, 8 to 12 inches in depth, carrying a considerable percentage of sand. The soil rests on a light-textured brown loam, which at any point from 12 to 18 inches passes into a yellow sand. The sand usually changes to light gray in color in the lower portion of the subsoil. It is loose and incoherent when dry, though slightly sticky when wet. The type is very pebbly and bowldery and in most cases too stony to admit of cultivation. Occasionally the subsoil is very gravelly, but this condition is usually confined to the surface soil. Where erosion has been severe the sand stratum is exposed.

In places the subsoil of the type is heavier, being a yellowish-brown gritty clay loam, and the sand stratum is not encountered. The material in such areas contains considerable grit and bowlders throughout the subsoil section and is rather compact and tough. There are also spots where the surface soil has been largely removed, and in such spots the 3-foot section consists of sand, pebbles, bowlders, and clay.

The type is very inextensive and occurs as small patches throughout the eastern part of the county. Most of the areas are confined to the section drained by North Blackbird and South Blackbird Creeks.

The Thurston loam occupies a position similar to the Carrington silt loam—i. e., along the lower slopes of streams and points of hills between drainage ways. The type is excessively drained and is rather droughty. It is subject to destructive erosion. The soil is glacial in origin. Most of the bowlders are quartzitic and granitic.

Most of the type is in prairie grasses. A small portion is in timber. It is largely utilized for pasture and scarcely any of the type is devoted to the production of crops.

THURSTON SANDY LOAM.

The Thurston sandy loam, as mapped in Thurston County, is typically a medium-brown to dark-brown, heavy sandy loam, with a depth ranging from 8 to 12 inches. The soil rests on a lighter textured brown sandy loam, which at any point between 12 and 18 inches passes into a yellow or brownish-yellow, loose, incoherent sand. The type is exceedingly variable in texture and color. In texture it ranges from a loam to a sand and in color from light brown to dark brown. The variations are of too irregular distribution to be shown as separate phases or types on the map.

Where the sand stratum has been exposed by erosion the soil is a light-brown loamy sand to sand and is subject to wind erosion. This variation occurs on the upper slopes throughout the type in small areas, locally termed "sand blows." Where the texture is a loam the soil is deeper and darker in color, and the sand stratum is usually not reached within the 3-foot section. Even where the texture is typical the Thurston sandy loam varies from a light-brown, shallow soil on the steeper slopes and points of hills to a dark-brown, deep soil on the lower slopes and draws. Included within this type are small unmapped areas of Marshall and Knox silt loam, with a slight admixture of sand.

The type is free from gravel and boulders, though it carries considerable coarse sand. The quantity of organic matter varies with the color of the soil.

The Thurston sandy loam occupies the lower and middle slopes and lower situations adjacent to Logan and Middle Creeks. The slopes are moderately steep. It always lies lower than the original constructional surface of the Marshall silt loam, though not lower than that type as a whole. The type is thoroughly drained and is subject to considerable erosion. Where the type carries considerable silt and organic matter the soil is quite retentive of moisture, though where it is low in these constituents the drought-resisting power is low. The Thurston sandy loam is derived from the sand stratum underlying the plains loess. It was originally covered by a growth of prairie grasses.

Most of the prairie sod has been broken and about 80 per cent of the type is now devoted to the staple farm crops. Corn is the leading crop and yields on the average 20 bushels per acre. Considerable oats and some wheat are grown. Oats produce 20 to 25 bushels and wheat 10 to 20 bushels per acre. Alfalfa does fairly well and yields 2 to 3 tons per acre. On the light-colored spots and sand blows the crop yields are very low. Where the type receives liberal applications of barnyard manure crop returns are 25 to 35 per cent higher than those stated above, but it is only on a few farms that large numbers of stock are kept and considerable manure produced. Where the manure is applied in spring the crops are apt to suffer from lack of moisture. Millet yields about 2 tons an acre and wild hay one-half to 1 ton. Some sorghum is grown. Truck crops do well, especially watermelons and muskmelons, but they are grown only for home use.

No definite crop rotation is practiced. As the land drifts, most of the type is plowed in the spring. Check-rowed corn, according to reports of farmers, does as well as listed corn. Hardly any green manuring is practiced.

Land values on the Thurston sandy loam range from \$65 to \$125 an acre, depending on location and improvements.

THURSTON SAND.

The soil of the Thurston sand is a medium-brown to dark-gray loamy sand to sand, 4 to 8 inches deep, carrying a high percentage of coarse sand. It contains a fairly high quantity of organic matter, which is being rapidly depleted. The subsoil consists of a loamy, incoherent yellow sand, which when wet is slightly sticky.

The type is confined to a small area immediately south of Thurston and a number of small areas northwest of that place. The topography is gently undulating, and the elevation is about 10 to 15 feet above the level of the Wabash silt loam. This land is apparently an old terrace whose topography has been so much modified by wind action that it no longer resembles a bench. The other areas occur as small spots on the slopes of the Thurston sandy loam.

The soil is excessively drained, leachy, and unretentive of moisture. Most of the type is under cultivation, but yields are very low, and crops are apt to lack vigor. The type is subject to a form of wind erosion locally termed "sand blow." Keeping the land in cover crops as much of the year as possible tends to retard this. When heavily manured the corn yield is about doubled.

LINDLEY SERIES.

The Lindley soils range from light brown to yellowish brown in color. The subsoils are yellowish brown to faintly reddish brown and are usually heavy sandy clays in texture. The soils are derived from old glacial drift; usually the Kansan, and carry a moderate to low content of lime. The topography is rolling and is due to erosion. So far as mapped, these soils do not occur in the areas of the younger glacial deposits. In this survey only the silt loam type is identified.

LINDLEY SILT LOAM.

The soil of the Lindley silt loam is a brownish-yellow or light-brown silt loam, 6 to 8 inches deep. It is heavier than that of the Knox silt loam, though friable and mellow under favorable moisture conditions. The subsoil is a yellowish-brown silty clay loam to silty clay, approaching in places a clay loam. It is rather compact and slightly plastic.

Throughout the profile the soil material is characterized by small gravel and gritty particles. A few large boulders and cobblestones are encountered in this type, but they are rarely so abundant as to interfere with cultivation. Lime concretions are numerous throughout the soil section and, where erosion has been severe, are found scattered on the surface. The soil is very low in organic matter.

This type is small in extent, covering an area of less than 1 square mile. It occurs mainly on points of hills and sharp divides. The soil is derived from the Kansan drift sheet, and naturally occupies lower elevations than the Knox silt loam.

Most of the type is used for pasturage, though some small fields are in corn. Corn at the time of the survey was yellow and stunted in growth, and only in places where the soil had received a heavy application of barnyard manure did the crop make a healthy and satisfactory growth.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Lindley silt loam:

Mechanical analyses of Lindley silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
371622.....	Soil.....	0.0	0.6	0.6	3.6	9.7	69.2	16.2
371623.....	Subsoil.....	.0	.4	.4	2.0	14.8	66.4	16.2

WAUKESHA SERIES.

The surface soils of the Waukesha series are dark brown to black; the subsoils are yellow. These soils are derived from water-assorted glacial débris deposited in broad, filled-in valleys or as outwash plains and terraces. The topography is mainly flat to undulating, and drainage is good. In Thurston County only the silt loam is mapped.

WAUKESHA SILT LOAM.

The soil of the Waukesha silt loam is a dark-brown to black, moderately heavy silt loam, ranging in depth from 10 to 20 inches, with an average depth of about 12 inches. The soil is high in organic matter and has a friable structure. It grades rapidly through a thin layer of brown into a yellowish-brown, more compact and heavy silt loam. There is a slight concentration of clay in the upper portion of the subsoil, resulting in a granular structure. However, the granules are easily broken down and the subsoil is comparatively friable. The substratum and occasionally the lower portion of the 3-foot section are highly calcareous. The soil profile of the Waukesha silt loam resembles that of the smoother areas of the Marshall silt loam.

The Waukesha silt loam covers 9.2 square miles and is largely confined to discontinuous terraces along Logan Creek. There are 3 divisions of terraces, low, medium, and high, lying 10 to 20 feet, 30 to 40 feet, and 80 to 100 feet, respectively, above the present

flood plains. The low and the medium terraces are flat and bench-like and have few streams. The surface of the high terrace is in general flat, but in detail it is more or less eroded.

The type is well drained. Owing to its high organic-matter content and friable structure, the soil withstands drought over a protracted period, though not so well as the Marshall silt loam.

The type is derived from colluvial and alluvial silts more or less modified by erosion. The material is loesslike and is described as a valley form of loess in Nebraska.¹

The type was originally in prairie sod and the same grasses are native to this soil as to the upland soils. Approximately 90 per cent of the type is under cultivation and is devoted to the general farm crops grown in the county. About two-thirds of the soil area is devoted to the production of corn, to which it is admirably suited. Corn yields 30 to 45 bushels per acre, depending largely on the thoroughness of cultivation and fertilization. Oats are grown rather extensively and produce 20 to 35 bushels per acre. Only a small acreage is devoted to winter wheat, but it is gradually increasing. Wheat returns 15 to 25 bushels per acre.

The chief hay crops are clover and timothy and alfalfa. In wet seasons clover and timothy do well, yielding $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. Alfalfa is a more certain crop and is gradually taking the place of timothy and clover. It produces 3 to 5 tons per acre. Usually 3 cuttings are made a season and occasionally 4. Enough potatoes are generally grown to supply the home demand.

No definite crop rotation is practiced. The system of managing farms on this type is similar to that on the Marshall silt loam. The general tendency is to grow less corn, more wheat and alfalfa, and to keep more live stock on farms of this type.

If time permits, stubble land is usually plowed in the fall. Most of the corn is listed, though some check rowing is practiced. Where the land is thoroughly disked before listing higher yields are obtained. The type is very easy to handle and can be cultivated under a wide range of moisture conditions. A small quantity of barnyard manure is applied every 7 to 8 years. Where 12 to 15 loads of manure are applied per acre farmers report an increase of 20 per cent in the yield of corn, and of 20 to 50 per cent in the yield of oats. Deeper plowing has also resulted in higher yields. The productive capacity of this soil has been greatly impaired by the continuous growing of corn and by shallow plowing.

The Waukesha silt loam ranges in price from \$125 to \$225 an acre, depending on the improvements and location.

¹ Unpublished manuscript by G. E. Condra.

In the table below are given the average results of mechanical analyses of samples of the soil and subsoil and a single analysis of a sample of the lower subsoil of the Waukesha silt loam:

Mechanical analyses of Waukesha silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
371607, 371610.	Soil.....	0.1	0.3	0.2	1.6	10.3	66.2	21.3
371608, 371611.	Subsoil.....	.1	.6	.3	1.4	9.3	66.4	21.6
371609.....	Lower subsoil...	.4	.6	.4	1.1	4.6	56.6	36.2

SCOTT SILT LOAM.

An area of Scott silt loam covering a few acres about 4 miles northwest of Pender has been included with the Waukesha silt loam and is not shown on the map, on account of its small size.

It occupies a depressed basin originally poorly drained, but recently drained by ditching. The soil is a dark-gray to black, smooth and velvety silt loam, compact and rather plastic. The upper subsoil is light gray in color, friable in structure, and is a silt loam containing some very fine sand. Usually at 24 to 30 inches the subsoil becomes a dark-blue, heavy silty clay faintly mottled with brown spots. The structure is compact and rather plastic.

SIoux SERIES.

The Sioux series comprises dark-brown to black terrace soils overlying lighter colored, calcareous subsoils. The subsoils are underlain by a substratum of gravel at varying depths. The series occurs in the glaciated region of the Northwestern Great Plains. In Thurston County the series is represented by the Sioux loam.

SIoux LOAM.

The soil of the Sioux loam consists of a dark-brown loam to silty loam, 8 to 12 inches deep, underlain by a brown loam of practically the same texture as the surface soil. At any point below about 20 inches the subsoil becomes a loamy sand to sand. The texture becomes lighter with depth, and in the lower portion of the subsoil there is usually very little silt or clay in the sand stratum. On the higher situations and knobs the sand comes closer to the surface, while in depressions and flat areas the sand is usually not reached within the 3-foot section. All facts gathered from farmers indicate that the sand stratum is general under this type. The type is fairly high in organic matter.

A deep phase of this type consists of a dark-brown loam to a depth of 12 to 15 inches, carrying a high percentage of medium sand. The soil rests on a brown silty loam to loam which does not contain so much sand as the surface soil. Owing to its irregular distribution, it was not practicable to show this phase on the map.

A few small areas of soil a little more sandy than typical, and considered sandy enough for sandy loam, were encountered northwest of Thurston. This soil is similar to the loam in all respects, except its high content of sand, but on account of the small area occupied it has not been shown on the map separately.

The Sioux loam covers 3.4 square miles and is entirely confined to the Logan Valley. The largest areas occur on the east side of Logan Creek, southwest and northwest of Thurston. The type occurs as a medium-high terrace along Logan Creek about 20 to 30 feet above the present flood plain. Its surface is generally flat, although slightly relieved by low ridges, knobs, shallow depressions, and a few streams. Owing to the sandy subsoil, the Sioux loam is provided with excellent drainage. During long droughts the soil suffers considerably from lack of moisture, especially where the sandy subsoil lies close to the surface.

The upper portion of the soil section is derived from alluvial silts and the lower portion from alluvial sands, underlying the thin layer of fluvial silts.

Originally this type was covered with the prairie grasses common to this region. Practically all of it is now under cultivation. Corn is the leading crop and is well suited to this soil. In a normal season it yields 35 to 45 bushels an acre, though under more favorable conditions higher yields are obtained. Oats, wheat, clover and timothy, and alfalfa are of minor importance. Oats produce 30 to 40 bushels per acre, wheat 20 to 25 bushels, clover and timothy $1\frac{1}{2}$ to 2 tons, and alfalfa 3 to 4 tons. Potatoes do well, and farmers aim to grow enough for home use. There is a great lack of proper rotation, and frequently a crop occupies the same field for a number of years.

Owing to its stone-free nature, smooth surface, and friable structure, this type is very easily handled. Except when cultivated while too wet, there is no tendency for the soil to clod. Little barnyard manure is applied, except in the less productive spots. All crops respond noticeably to applications of manure.

Land values range from \$90 to \$125 an acre, depending on location and improvements.

WABASH SERIES.

The Wabash soils are prevailingly black, ranging to dark brown, and contain a high percentage of organic matter. The subsoils are

gray to brownish gray. These soils are developed in the first bottoms of streams in the Central Prairie States. They extend for long distances along the Mississippi River. The material is derived principally from the loessial and associated soils of the region. These soils have a flat topography and are poorly drained. In this county the Wabash silt loam, loam, and clay types are mapped.

WABASH SILT LOAM.

The soil of the Wabash silt loam consists of a dark-brown to black, smooth, friable silt loam, 10 to 24 inches deep. It is underlain by a dark slate colored or almost black, heavy silt loam to silty clay loam, which at any point from 24 to 30 inches becomes faintly mottled with brown, the mottling becoming more conspicuous with depth. Occasionally the subsoil changes to dark gray. Cross sections of drainage ditches on the Logan Creek first bottoms show that at a point between 4 and 6 feet a light-gray, heavy silt loam, streaked with brownish iron stains, is encountered.

Lime concretions and organic shells occur in the subsoil, but more abundantly in the deeper substratum. The subsoil is compact and has a granular structure. The change from soil to subsoil in texture, structure, and color is very gradual and not infrequently there is no change within the 3-foot section, except that the subsoil is more compact.

A minor variation in the type is found along small streams about 3 miles east of Rosalie. The soil is a very dark gray to black, heavy silt loam, with an average depth of 12 inches, underlain by a dark-gray, heavy silt loam, slightly streaked with rusty brown. At any point from 24 to 36 inches a black, heavy silt loam is reached, which is apparently an old soil upon which more recent wash has been deposited. In this locality the bottom lands are mere sags in the upland and the stream gradient is very small. The drainage is very poor and land of this variation is entirely utilized for hay and pasturage. The area at the head of South Omaha Creek, immediately north of Rosalie, is also poorly drained and conforms to the description just given.

In Logan Valley a heavy phase, approaching a silty clay loam, is encountered. It covers the poorly drained areas, shown by marsh symbols, south of Rosalie; a part of section 34 immediately south of Pender, and small areas adjacent to the upland or terraces on the west side of Logan Creek. The soil to a depth of 18 to 20 inches is a black, extremely heavy silt loam, approaching a silty clay loam, and underlain by a very dark gray, heavy silt loam to silty clay loam. In places the upper portion of the soil proper is the heaviest part of the 3-foot section, while in others the subsoil

is the heaviest. Frequently the black color continues to a depth of 3 feet, becoming slightly lighter in the lower portion. This phase is very high in lime concretions, which give the subsoil a pronounced gritty feel.

A colluvial phase is mapped with the typical Wabash silt loam. It consists of a dark-brown to black, heavy silt loam, extending to a depth of 3 feet without any material difference in texture or color. The subsoil is somewhat more compact, though very friable. This phase occurs as colluvial fans at the mouths of small streams entering the main bottoms, and as gentle slopes between the bottom land proper and the upland or terraces. It is well drained and not subject to overflows, except for short duration by branch streams. Corn, oats, and wheat do well on this phase, though most of it is devoted to corn.

In a few local spots adjacent to the upland west and southwest of Pender shallow deposits of mucky material have developed. These areas occur where there is considerable seepage from the upland. Along the stream channel of Logan Creek the surface soil is coarser in texture and better oxidized, and frequently there are seams of sand in the soil section.

The Wabash silt loam is the most extensive bottom-land soil in the county, covering 63.9 square miles. It occurs as first bottoms along the streams and is subject to overflow.

The topography is flat and only slightly relieved in elevation by abandoned stream channels and cut-offs. Along Logan Creek a low, inconspicuous natural levee has been aggraded. The gradient of the main streams in the area, except those flowing directly into the Missouri River, is slight. Originally the drainage of this type was poor, but by clearing and straightening the channels of the streams the natural drainage has been much improved. The areas indicated by marsh symbols and a large part of the type adjoining the upland and terraces on the west side of the Logan Creek first bottoms are poorly drained. South of Rosalie two big ditches, shown on the accompanying map, have been constructed. Tiling costs \$20 to \$30 an acre. Some tile drainage has been done, with profitable results, corn yielding 10 to 20 per cent more than before.

Originally most of this type was covered with water-loving grasses, such as Wyoming bluegrass, crowfoot grass, bluestem, and slough grass. A narrow strip along the channel of the main streams and the narrow first bottoms were forested with elm, ash, willow, cottonwood, and black walnut. About 30 per cent of this type is now devoted to the production of staple crops. On well-drained areas practically all of it is utilized for the production of corn, which returns higher yields than any other soil type in the county. Yields of 45 to 55 bushels per acre are obtained, and with proper cultivation

in favorable seasons as much as 60 to 70 bushels has been obtained. Where the soil has been in corn for a number of years and is well drained wheat does well, yielding 20 to 40 bushels per acre. Not much wheat is grown, as it is subject to rusts and is apt to lodge. Kherson oats do fairly well, yielding 30 to 50 bushels an acre. The long-strawed and late varieties are apt to lodge. A small acreage of barley is grown, with yields of 20 to 40 bushels per acre. In common with the other small-grain crops, it is apt to lodge.

On the higher, better drained areas alfalfa does remarkably well, yielding 3 to 5 tons per acre. Timothy is an excellent hay crop on this type and cuts $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre. Alsike clover does well, yielding 2 to 3 tons of hay per acre. White clover makes a luxuriant growth in pastures. Some potatoes are grown but the quality is rather inferior. Potatoes yield 125 to 175 bushels per acre.

Most of this type is in hay land and pasture. Wild hay produces 1 ton to 2 tons per acre. After the first few cuttings the yield of wild hay decreases considerably, but with a small application of barnyard manure the grass is rejuvenated. Owing to the fact that a large part of the type affords good pasturage, cattle raising and feeding have been extensively developed.

A one-crop system prevails on this type, though occasionally corn is rotated with oats and wheat. It is not uncommon for a farmer to report that a certain field has been in corn for 10 years or more. A rotation practiced by a few of the best farmers consists of three years corn, followed by one year of oats and one year of wheat, after which the land is seeded to clover and timothy, which is left from one year to three years. The bottoms do not give very profitable returns as hay lands and are being broken up and drained.

The flat topography, silty texture, and desirable structure make this an easy soil to handle. The soil can be cultivated under a rather wide range of moisture conditions, though if plowing is done when the soil is too wet it bakes and forms hard lumps. The heavy phase of this type requires more careful attention, and if cultivated when the moisture content is too high it puddles and forms clods which are difficult to reduce. Where the type is well drained it has been found that it is much easier to till and can be cultivated three or four days earlier in the spring. Fall plowing is generally practiced on this type, as the soil is usually too wet to plow in the spring. It is preferable to checkrow corn, because with listing the water stands in the furrows and is apt to drown out the crop.

Little barnyard manure is applied to this type, though it receives considerable droppings from live stock which pasture over a great part of it some time in the year. The Wabash silt loam is very drought resistant and crops seldom suffer from lack of moisture. The productiveness of the soil has been somewhat impaired owing

to the continuous growing of corn. The important problem that confronts the farmer on this type is that of drainage, though the prevention of overflows is a matter of no little concern. It is not uncommon for the bottom lands to be overflowed twice a year—in early June and in September.

The value of land on this type ranges from \$80 to \$150 an acre, depending on location and drainage conditions. The well-drained land rents for \$6 to \$7 an acre.

WABASH LOAM.

The Wabash loam is a dark-brown to black, heavy loam to silty loam, 15 to 20 inches deep, carrying an appreciable quantity of fine sand. It is heavier than the typical Wabash silt loam and breaks up into granules. The soil rests on a brown, heavy loam which immediately passes into a mottled yellow and gray subsoil of the same texture. Where the type is better drained the subsoil is of a light-brown to brown color. Areas adjoining the Thurston sandy loam contain an appreciable quantity of sand and approach a sandy loam in texture.

The type covers only 1.7 square miles. It is entirely confined to first-bottom developments along the smaller streams in the north-western part of the county. It is closely associated with the Thurston sandy loam. The topography is flat and the drainage is generally inadequate. The native vegetation is similar to that on the Wabash silt loam.

Most of the type is in pasture. Some wild hay is produced, with yields of 1 ton to 1½ tons per acre. About 15 per cent of the land is devoted to the production of corn, which yields 40 to 60 bushels per acre.

The type ranges in price from \$80 to \$125 an acre, depending on drainage improvements.

WABASH CLAY.

The soil of the Wabash clay is a black to dark-drab, heavy clay, 6 to 8 inches deep, containing a high percentage of organic matter. The surface soil is extremely hard when dry and waxy and plastic when wet. It is underlain by a plastic, dark slate colored, heavy clay, which continues to the depth of 36 inches. The lower portion of the subsoil is usually lighter in texture and frequently lighter in color, being dark gray. Where the type is well drained a lighter colored material, gray mottled faintly with brown, begins at 15 to 20 inches. This stratum merges at a point between 24 and 30 inches into bluish gray, mottled rather conspicuously with yellow and reddish brown. In this variation, also, the texture becomes lighter with depth, being a silty clay loam in the lower portion of the subsoil.

Immediately northeast of Phillips Store a small area of Cass clay is mapped with this type. The soil consists of a dark-drab silty clay to clay to a depth of about 12 to 18 inches, where a drab-colored silty clay is encountered. At any point from 30 to 40 inches a yellowish-gray very fine sandy loam is reached. This included type and the area 1 mile south of Phillips Store occupy a recently abandoned channel and are about 6 to 8 feet lower than the typical Wabash clay. The Cass clay supports a good stand of alfalfa and corn.

The type is small in extent, covering only 2.1 square miles. It is confined to the first bottoms of the Missouri River.

The topography is flat and the soil is poorly drained, owing to its low position and impervious subsoil. The most poorly drained area is indicated by marsh symbols. No artificial drainage has been provided.

The type undoubtedly marks a still older channel of the Missouri River, which has been silted in by slowly moving waters and back-water during overflows.

About 25 per cent of this type is in hay land and pasture. Wild hay produces 1 ton to 1½ tons an acre. The area 1 mile south of Phillips Store is covered mainly with a thick growth of willow. Wheat and corn are the predominant crops, with a smaller acreage of oats, barley, and alfalfa on the better drained portion of the type. The Wabash clay is very well adapted to wheat growing and yields 25 to 50 bushels per acre, with an average of 35 bushels. Corn produces 40 to 45 bushels an acre, oats 30 to 60 bushels, barley about 30 bushels, and alfalfa 4 to 6 tons. Bluegrass and alsike do well. Winter wheat and rye are better nurse crops for alfalfa than either oats or barley. The Wabash clay is the most drought-resistant soil in the county, and crops rarely suffer from lack of moisture.

The type is the most difficult soil to handle in the county. When it is cultivated too wet the granules coalesce and form clods, which are difficult to reduce. In rainy seasons it is very difficult to get the soil in proper tilth for crops. Large checks and cracks are common. Very little barnyard manure is applied to this soil.

The Wabash clay ranges in price from \$80 to \$100 an acre, depending on the drainage conditions.

SARPY SERIES.

The soils of the Sarpy series range from light gray to dark brownish gray or nearly black. They differ from the Wabash and Yazoo soils in having subsoils distinctly lighter in texture than the surface soils. This series is developed in the bottoms of the Mississippi and Missouri Rivers and their large tributaries. The material is alluvial in origin. Owing to their low positions, these soils

are subject to overflow, although the nature of the soil and subsoil is such that between the flood stages of the streams drainage is good. In general, the topography is flat. In Thurston County the Sarpy silt loam and very fine sandy loam are recognized.

SARPY SILT LOAM.

The Sarpy silt loam, to the depth of 8 to 10 inches, is a light-brown silt loam carrying a rather high percentage of very fine sandy loam. When dry the surface soil has an ashy-gray appearance. It is underlain by a yellowish-gray to light-gray very fine sandy loam containing a high percentage of silt. The subsoil is loose and open. Some yellowish iron stains are present. The change from soil to subsoil is very gradual and not infrequently there is no apparent change in color or texture within the 3-foot section. Seams of sand and clay and also old soil are apt to be found in any part of the soil profile. As the color indicates, the soil is low in organic matter.

This type occurs on the Missouri River first bottoms, where it covers 4.7 square miles. The largest area occurs about 5 miles north of Macy.

The type is well drained between high waters and has a flat, slightly ridged topography. The typical soil lies about 10 to 15 feet above the normal flow of the Missouri River and is rarely overflowed. The area immediately south of Phillips Store and the area skirting the Wabash clay in the same locality are considerably lower, lying about 3 to 5 feet above the normal flow of the Missouri River. They occupy an old abandoned channel, are poorly drained, and are subject to frequent inundations. Owing to the high water table this type is very drought resistant.

The oxbow-shaped area immediately south of Phillips Store and the large area about 5 miles north of Macy are chiefly covered with a thick growth of willow and poplar. The remainder of the type is devoted to the production of the staple farm crops. Corn is the principal crop and ordinarily yields 40 to 60 bushels per acre. On the lower lying areas in the vicinity of Phillips Store 80 to 100 bushels are obtained in favorable years. Wheat and oats meet with success but are not much grown. The type responds noticeably to manuring and with a good application the yield of corn is increased about 30 per cent.

No definite system of crop rotation is practiced. In general corn is grown for a series of years and is only occasionally rotated with a grain crop. In the vicinity of Phillips Store this type receives considerable manure, there being a large number of live stock kept. The soil is easy to manage and can be cultivated under a wide range of moisture conditions.

The value of this type ranges from \$50 to \$100 an acre, depending on the extent to which it is subject to erosion by the Missouri River.

The results of mechanical analyses of samples of the soil and subsoil of the Sarpy silt loam are shown in the following table:

Mechanical analyses of Sarpy silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
371634.....	Soil.....	0.0	0.1	0.1	1.0	8.9	74.5	15.5
371635.....	Subsoil.....	.0	.0	.1	.4	5.0	83.7	10.9

SARPY VERY FINE SANDY LOAM.

The Sarpy very fine sandy loam consists of a yellowish-gray to light-brown very fine sandy loam, 8 to 15 inches deep, underlain by a somewhat lighter colored and lighter textured very fine sandy loam. The subsoil is slightly streaked with yellowish iron oxides. There is no apparent change in the 3-foot soil section, except that the surface soil is slightly heavier in texture. Layers of fine sand, silt, and even clay are very common throughout the soil profile. The type includes small patches of fine sandy loam and sand. The soil is very low in organic matter.

This type is the most extensive one in the first bottoms of the Missouri River. It covers 7 square miles. The largest areas occur in the extreme northeastern part of the county. Smaller areas occur in the vicinity of Phillips Store and in the southeastern corner of the county. This soil is elevated about 8 to 10 feet above the normal flow of the streams. The surface is generally flat, though marked with slight ridges. When the Missouri River is low the drainage is thorough; at high-water stages the water level comes close to the surface and the lower lying areas are subject to overflow.

Most of the Sarpy very fine sandy loam supports a dense growth of willow, and where the type has not been changed by floods for some time it is forested, the growth comprising cottonwood, elm, box elder, and willow. Such areas are largely devoted to pasturage. The area lying north of Phillips Store and that in the southeastern corner of the county, besides a few small patches elsewhere, are in cultivation. Corn is the chief crop and yields 40 to 60 bushels per acre. In wet seasons the highest yields on the Missouri River first bottoms are obtained on this type. In dry years the soil suffers somewhat from lack of moisture, especially the light-textured spots. On the fine sandy spots the corn is usually yellowish and is stunted in growth. Watermelons, muskmelons, tomatoes, and potatoes do very well on this type, but their production is largely confined to home

requirements, though some are sold to towns in the eastern part of the county.

The Sarpy very fine sandy loam does not require heavy draft animals or strong farm equipment. It can be handled under any moisture condition, and if plowed when extremely wet the clods are easily reduced. In the vicinity of Phillips Store considerable manure is added, though the rest of the areas receive very little.

The land values of the Sarpy very fine sandy loam range from \$30 to \$80 an acre.

The following table shows the results of mechanical analyses of samples of the soil and subsoil of the Sarpy very fine sandy loam:

Mechanical analyses of Sarpy very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
371632.....	Soil.....	0.0	0.1	0.1	1.6	49.2	41.0	8.0
371633.....	Subsoil.....	.0	.2	.1	2.0	40.8	48.9	8.0

MISCELLANEOUS MATERIAL.

RIVERWASH.

Under the classification of Riverwash in Thurston County are included the mud areas, silty flats, and sand bars along the Missouri River. The material is mostly light-gray to almost white fine sand. There is very little coarse material.

The area adjacent to the bottom-land types at Phillips Store has been considerably modified by deposits from Blackbird Creek. The soil is slightly higher in elevation and consists of a brownish-gray very fine sandy loam to the depth of 15 inches, underlain by a yellowish-gray very fine sandy loam. The subsoil is conspicuously streaked with iron stains. The phase is in a transitional stage, and with its further development from successive deposits will pass into another soil type. It is covered with a rather dense and tall growth of willow and poplar.

Riverwash lies only a few feet above the normal flow of the river and is inundated with each slight rise. It is changed by every overflow, and even during the normal flow of the stream it is washed away in some places and built up in others. It is also modified by the action of the wind. Except for a few willows it is practically devoid of vegetation.

SUMMARY.

Thurston County is located in the northeastern part of Nebraska, bordering the Missouri River. It embraces an area of 387 square miles, or 247,680 acres. The topography ranges from almost flat

through rolling and steeply rolling to hilly and extremely dissected. The dissection in the eastern part of the county is about 400 feet, and in the western part 150 to 200 feet.

The county is drained by three streams, the Missouri River and Logan and Omaha Creeks, and their tributaries. The general direction of the drainage is to the southeast and as a whole the county is well drained.

The first permanent settlement in Thurston County was made in 1884, and the county was organized in 1889, with Pender as the county seat. There are two Indian reservations—the Omaha and Winnebago—in the county, which have a combined population of 1,000. Most of the white settlers have come from the surrounding counties.

The population of Thurston County is given in the 1910 census as 8,704.

No place in Thurston County is more than 8 miles from a railroad station, except in the southeastern corner of the county, where the distance ranges from 8 to 16 miles.

The rural free delivery of mail reaches practically all parts of the county and the telephone is in use to a considerable extent.

The climate of Thurston County is favorable for the production of the common staple crops, such as corn, oats, wheat, and alfalfa. The mean annual temperature is 49.5° F. and the annual precipitation averages 32 inches.

Grain farming is the chief type of agriculture practiced, though increasing attention is being directed to the production of pork, beef, and dairy products.

Corn, oats, wild hay, barley, wheat, timothy and clover, and alfalfa are the main crops. Potatoes and sorghum are grown to some extent.

Truck crops are grown on a small scale. There are no large bearing orchards except in the southwestern corner of the county.

The systematic rotation of crops is not in general practice and the adaptation of crops to the various soils has not been carefully studied.

Fourteen soil types, one phase, and Riverwash, representing 9 series, are mapped in Thurston County. They are classed in three groups—the upland soils, terrace (old alluvial) soils, and first-bottom (recent alluvial) soils.

The Marshall silt loam covers about three-fourths of the upland and is considered the best upland type for grain farming. Corn, oats, and wheat are the chief crops grown. It is a dark-colored loessial soil. The flat phase is of small extent. It is devoted to practically the same crops as the main type.

The Knox silt loam is a light-colored loess soil, being in reality an eroded phase of the Marshall silt loam. It is largely devoted to

alfalfa, which is the most profitable crop. Unless they are heavily manured, corn and the small grains are not usually profitable.

The Carrington silt loam is glacial in origin and occurs largely in the eastern part of the county. It is small in extent and is largely utilized for pasture and hay land.

The Lindley silt loam is glacial in origin, but is derived from a stratum which gives rise to a rather stony soil. It occurs on steep slopes along streams and low points between drainage ways. It is almost entirely utilized for pasture.

The Thurston sandy loam is derived from the sand bed underlying the loess. It is developed in the northwestern part of the county. Corn, oats, and wheat are the chief crops. It is not so productive a soil as the Marshall silt loam.

The Thurston sand is very limited in extent. The soil is subject to wind and water erosion. It is very unproductive and in places almost devoid of vegetation.

The Thurston loam is inextensive and is mostly covered with prairie grasses.

The Waukesha silt loam belongs to the terrace group of soils, and is derived from old alluvial silts deposited at a time when the streams were flowing at a higher level than at present. It is considered a desirable soil and is used largely for corn, oats, and wheat.

The Sioux loam is a terrace soil derived in part from a thin veneering of fluvial silts and the basal sands of the terraces. It is not so drought resistant as the Waukesha silt loam. The crops are similar. In places the soil is sandier than typical.

The Wabash silt loam is the most extensive first-bottom soil. Generally it is in need of better drainage. Where well drained, it is the best corn soil in the county, though not nearly so well adapted to wheat and oats.

The Wabash loam is a very inextensive type. It is confined to the northwestern part of the county and is developed in the Thurston sandy loam areas. It is largely used for hay and pasturage.

The Wabash clay is the heaviest soil in the county. Wheat and corn are the principal crops.

The Sarpy silt loam is an alluvial soil and occurs entirely on the Missouri River first bottoms. Corn is the chief crop grown.

The Sarpy very fine sandy loam is the most extensive soil on the Missouri River bottoms. It is largely devoted to corn, but the forested areas are used for pasturage.

Riverwash comprises mud areas, silty flats, and sand bars along the Missouri River. It is constantly being changed by stream erosion and typically is devoid of vegetation.

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LEGEND

LEGEND

Sil —Silt loam
Sicl—Silty clay loam
Yfs1—Very fine sandy loam
Ls —Loamy sand
Sl —Sandy loam
S —Sand
L —Loam
C —Clay

1 1/2 0 1 2 3 4 Miles

Scale 1 inch = 1 mile

A. Hoerr & Co Lith. Baltimore, Md.

Field Operations
Bureau of Soils
1914


CONVENTIONAL SIGNS

CULTURE
(printed in black)

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ves, Jetties, Breakw
vee, Lighthouse, For

DOUBLE BONDS	MELTING POINT
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1	20
2	30
3	10
4	20

by roads	Rail
rails	Steam and



GEM

Quarry Bluff, Esc.

land Triangular

Figure 1 consists of two schematic diagrams. Diagram (a) shows a square box containing a random distribution of small circles representing particles. Diagram (b) shows a square box containing a segregated distribution of particles, with some particles clustered together and others isolated.

LAND

Boundary Lines

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map. Variations from this usage appear in some maps of earlier dates.